stratigraphic unit as those found in the late 1950's, and it is probable that this unit contains other bones not yet exposed by erosion.

Merrilees (1968: 15) concluded that the *Zygomaturus trilobus* remains found by the Whites in the 1950's are contemporaneous with artifacts he found in similar sediments in the district. Recently, Wyrwoll and Dortch (1978) reported the association of artifacts with a mandible of *Zygomaturus trilobus* in the nearby Greenough River. Investigations now in progress may provide more evidence for the antiquity of the Murchison River fossils and the possible causes of this species' extinction.

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WATERFOWL UTILIZATION OF LAKE CLAREMONT DURING 1977

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INTRODUCTION

Lake Claremont, situated in the Perth suburb of Claremont, lies in a depression in the Spearwood System of coastal sand dunes. It is now a permanent freshwater lake, which covers an area of approximately 20 ha at high water and has a maximum depth of 2.5 m. Until 1918 the area comprised a central swamp zone with paper bark trees *(Melaleuca rhaphiophylla)* and two small permanent waterholes surrounded by an area of brown sandy soil supporting Blackboys *(Xanthorrhoea preissii)* and Tuarts *(Eucalyptus gomphocephala)* (Evans and Sherlock, 1950). The lake is thought to have formed after 1920 when several successive years of high rainfall elevated the metropolitan water table (Serventy, 1948; Evans and Sherlock, 1950; Seddon, 1972). Only remnants of the original vegetation now remain since the establishment of sporting amenities and picnic area around the lake. Within Lake Claremont small areas of the sedge *(Scirpus lacustris)* and Bulrush *(Typha orientalis)* are the only living emergent macrophytes. Some skeletons of dead paperbarks also remain. The area was known as Butler's Swamp until July 1954 when the name Lake Claremont was formally adopted *(West Australian,* July 23, 1954).

Along with other water bodies on the Swan Coastal Plain, Lake Claremont is utilized by birds as an area for refuge from storms and the activities of man (e.g. Silver Gull, *Larus novaehollandiae);* for feeding (e.g. Black-winged Stilts, *Himantopus himantopus);* and for breeding and nesting (e.g. Black Duck, *Anas superciliosa;* Coots, *Fulica atra* and Black Swans, *Cygnus atratus)* (Serventy, 1948; Seddon, 1972). Particularly in the summer birds utilize Lake Claremont in large numbers; many waterfowl such as the Black-winged Stilt and the Black Duck migrate inland in winter when water bodies in the hinterland become available for exploitation by them (Serventy & Whittell, 1967). Emory *et al.* (1975) counted the number of birds utilizing Lake Claremont on 15 occasions from 1972 to 1974, mainly in the latter months of 1972 (5 times from September to December) and 1974 (8 times from September to November). They recorded fewer birds present on the lake in 1972 and attributed this to the higher level of salinity of the water over that period.

It was planned to monitor the bird life utilizing Lake Claremont (as part of the First Year Zoology 110 Course at the University of Western Australia*) from March until September 1977, that is through a season infrequently sampled by Emory *et al.* However, because of the drought experienced in the Perth metropolitan area during 1977 the study fortuitously provided an excellent opportunity to check the validity of Emory *et al's* suggestion that on Lake Claremont bird numbers decline when the salinity level increases. Data from the fieldwork in 1977 forms the basis of the present paper.

MATERIALS AND METHODS

Five observation sites were selected along the western half of the lake, and each site was manned by 2 students*. Each observation site covered an area of aproximately 100 x 75 m; only the western half of the lake was surveyed. Counts of bird numbers and species were made from 10:00 hours to 12:00 hours on the 6 days specified in Table 1. Although salinity levels were monitored on each sampling period using a Salt Bridge type MC5 Salinity/Temperature meter, the results are not presented here because of doubt concerning reliability of the instrument. Instead we quote salinity levels and water depths data kindly provided by the Metropolitan Water Board.

TABLE 1.—WATERFOWL SCORED DURING THE PRESENT STUDY AT LAKE CLAREMONT.

	27.3.77	3.4.77	19.4.77	5.6.77	3.7.77	14.9.77
Black Duck	192	59	96	113	56	43
Grey Teal	12	8	5	21	5	18
Silver Gull	560	300	20	150	0	15
Coot	120	21	43	40	35	34
Black Swan	4	3	1	4	5	2
Swamp Hen	3	2	2	0	0	0
Black-winged Stilt	145	74	53	0	10	0
Little Pied Cormorant	7	0	0	0	0	5
Pelican	1	0	0	0	0	0
Pink-eared Duck	0	0	0	0	0	4
Chestnut Teal	0	0	0	0	0	1
Blue-billed Duck	0	0	0	0	0	3
Muscovy Duck	0	0	0	0	0	1
TOTAL	1044	467	220	328	111	126
SPECIES	9	7	7	5	5	10
H^{1*}	1.31	1.10	1.35	1.21	1.21	1.72
J^{1**}	1.37	1.30	1.59	1.73	1.73	1.72

*Shannon Weiner Diversity Index

**Evenness $J^1 = \frac{H^1}{\log S}$

RESULTS AND DISCUSSION

A total of 13 species of waterfowl were recorded at Lake Claremont during the present study (Table 1), a number which compares favourably with the 13 and 16 species recorded in 1972 and 1974 respectively by Emory *et al.*

The species present on the lake at any one time depend largely upon the migrating and reproductive habits of the waterfowl. Birds known to breed on Lake Claremont e.g. Black Duck, *Anas superciliosa* (J. Dell pers. comm., mating behaviour observed in September 1977); Coot, *Fulica atra* (courtship observed in September 1977); Black Swan, *Cygnus atratus*, and possibly also Grey Teal, *Anas gibberifrons* (Serventy & Whittell, 1967, describe the species as an opportunistic breeder, it probably breeds on metropolitan lakes in dry years) appear to persist there throughout the year. The Black-winged Stilt, *Himantopus himantopus*, which was present

*The students involved in the study, all members of the 1977 Zoology 110 Course, University of Western Australia, were J. Adamson, M. Beros, M. Bosca, J. Denny, J. Lloyd, K. Maley, R. Mitchell, R. Petterson, A. Prins, J. Power and T. Thornton.

in high numbers in March 1977 after which times its numbers gradually declined (Table 1), was not recorded by Emory *et al.* This species feeds on the exposed mudflats of Lake Claremont during summer months and migrates inland to salt lakes in the wheatbelt after the first rains in the metropolitan area. Silver Gulls, *Larus novaehollandiae,* were abundant in March and April 1977, when they were observed to be mostly resting. Members of this species breed on offshore islands in spring and autumn (Serventy & Whittell, 1967), but large numbers seek refuge on coastal water bodies during storms (Emory *et al.,* 1975).

The Pink-eared Duck, *Malacorhynchus membranaceus,* also observed breeding on Lake Claremont (Rooke, 1963); Chestnut Teal, *Anas castanea,* and Blue-billed Duck, *Oxyurus australis,* were all observed once, and then on the same day, i.e. September 14, 1977. These species and others recorded by Emory *et al.* (1975, Table 1) but not observed during the present study, e.g. Dusky Moorhen, *Gallinula tenebrosa;* Little Grebe, *Podiceps novaehollandiae,* and perhaps the Hoary-headed Grebe, *Podiceps poliocephalus,* are all predominantly non-migratory waterfowl and apparently persist about Lake Claremont in low numbers. Their infrequent sighting during the present study is probably due to sampling vagaries. Other species appear to visit Lake Claremont only sporadically. Those observed in the present study include the Little Pied Cormorant, *Phalacrocorax melanoleucos,* and Pelican, *Pelecanus conspicillatus.* In the same category are the Great Crested Grebe, *Podiceps cristatus;* Little Bittern, *Ixobrychus minutus,* and Reed Warbler, *Acrocephalus stentoreus,* recorded by Emory *et al.,* (1975).

The numbers of waterfowl counted in this study were higher before the first rains of the year, which fell on April 30, 1977, than after, i.e. while the higher salinity levels persisted in the lake (Table 5). Also, the diversity of the waterfowl population (Shannon Weiner diversity index H^1, evenness J^1) was lowest during the winter months of 1977, presumably determined by the departure of certain species for inland areas. While it is difficult to draw strong conclusions from data gained from studies with such limited sampling programmes and different sampling times and strategies, our data (Table 1) together with the 1974 data of Emory *et al.* indicate that waterfowl numbers at Lake Claremont during both these years were consistently higher than during the latter months of 1972.

TABLE 2.—SUMMARY OF WATERFOWL SEEN AT LAKE CLAREMONT
By EMORY *et al.* (1975)

	7.4.72	5.9.72	24.10.72	24.11.72	8.12.72	23.12.72	8.1.73	21.9.74	23.9.74	24.9.74	6.10.74	13.10.74	20.10.74	3.11.74	10.11.74
TOTAL BIRDS	114	81	93	92	56	39	70	129	15	51	7223	7292	919	924	948
SPECIES	8	8	12	10	10	7	8	11	5	9	12	13	12	14	13
H^1*	1.62	1.64	1.86	1.80	1.79	1.62	1.80	1.70	1.49	1.95	0.13	0.18	0.83	0.88	0.96
J^1**	1.79	1.81	1.72	1.80	1.79	1.91	1.99	1.63	2.13	2.04	0.12	0.16	0.767	0.76	0.86

*Shannon Weiner Diversity Index

**Evenness $J^1 = \frac{H^1}{\log S}$

The diversity indices for the Emory *et al.,* data (summarised here in Table 2) have also been determined and it would appear that the diversity of the waterfowl on Lake Claremont was not significantly different during 1972 and 1977. However in 1974 a big reduction in diversity of the population was seen with the influx of large numbers of Silver Gulls.

Assuming that the reduction in numbers was not due to sampling error, why then were there fewer waterfowl utilizing Lake Claremont in

1972? Emory *et al.* proposed two possible answers to this question; namely the reduction was due to differences in the timing of the seasons, or to differences in the water quality, that is salinity level, between 1972 and 1974. Greater emphasis is given to the second suggestion. We question both suggestions as being too simplistic, particularly when the climate operating over Western Australia since 1970, and the biology of the waterfowl are taken into account.

TABLE 3.—ANNUAL RAINFALL TOTALS FOR VARIOUS LOCALITIES (mm)

	1970	1971	1972	1973	1974	1975	1976	1977	Average
Perth	908	800	613	975	939	682	711	607	879
Brookton	408	411	264	465	507	411	468	135	468
Merredin	352	385	387	378	491	335	309	204	331
Kalgoorlie	171	126	151	385	418	420	—	—	263
Meekatharra	145	258	168	354	330	442	140	44	229
Esperance	—	854	554	620	575	—	—	—	705
Lake Grace	310	415	212	367	508	326	395	287	362
Narrogin	555	561	311	529	673	484	467	443	509
Pemberton	1337	1266	934	1429	1129	1120	—	—	1245

TABLE 4.— INTERRELATIONSHIP OF RAINFALL AND WATER LEVEL AT LAKE CLAREMONT
(Dates shown in brackets)

	Rainfall (mm)	Water depth (m) Max.	Min.	Average
1970	908	2.332 (4.8.70)	1.521 (14.4.70)	1.933
1971	800	2.045 (5.10.71)	1.689 (3.3.71)	1.851
1972	613	1.865 (28.8.72)	1.317 (7.4.72)	1.551
1973	975	2.340 (30.7.73)	1.600 (2.2.73)	1.993
1974	939	2.450 (11.11.74)	1.510 (26.3.74)	1.977
1975	682	2.182 (1.9.75)	1.676 (7.4.75)	1.888
1976	711	1.951 (8.9.76)	1.371 (5.4.76)	1.644
1977	607	1.660 (4.9.77)	1.206 (3.5.77)	1.390

TABLE 5.—SALINITY OF LAKE CLAREMONT
(NaCl measured in mg/l)

	J	F	M	A	A	S	O	D
1972				5,600				
1973								580
1974			1,050	1,040	620	500		
1975	1,020		1,320			755		
1976			2,770				1,135	
1977		4,220					1,740	

The annual rainfall for Perth and several country localities since 1970 is shown in Table 3, the inter-relationship of rainfall and the water level at Lake Claremont since 1970 is shown in Table 4, and salinity readings for various months at Lake Claremont are shown in Table 5. The climatic data and the data on the condition of Lake Claremont collected by us indicate that Lake Claremont was in a similar situation in 1977 as it was in 1972, that is, the annual rainfall for both years was well below average, the corresponding water level of Lake Claremont was low, and salinity levels were high. Therefore although Lake Claremont was in fact in "poorer" condition with respect to high salinity levels in 1972 as compared with 1974, it was no more severe than that experienced in 1977. Therefore this explanation given by Emory *et al.* cannot be regarded as

the only reason for lower waterfowl numbers. In fact the number of waterfowl utilizing Lake Claremont will depend upon a number of factors, probably with quite complex interrelationships. Besides salinity levels, consideration must be given to:

(a) the area and water available elsewhere for breeding and feeding. There were presumably fewer refuges available for exploitation by waterfowl in inland areas in 1972, because of the lower rainfall, and consequently greater numbers should have been observed on the permanent water bodies of the Swan Coastal Plain.

(b) the feeding biology of some species with respect to the area of mudflat exposed. This would affect such species as the Black-winged Stilt which feed predominantly on such areas.

(c) the incidence of disease in low rainfall years, for example, botulism. This explanation for the lower numbers in 1972 cannot be ignored, although as yet we have not been able to find any published information in support of this possibility. Algal poisoning was responsible for killing hundreds of birds and fish in Lake Monger in January 1971 *(West Australian,* February 4, 1971). Also 80 dead fish were found in Lake Claremont in January 1971 *(West Australian,* January 18, 1971).

(d) the effect of weedicide and pollutants on the waterfowl population. During July/August 1972 Lake Claremont was sprayed with a weed killer to eradicate reeds which were threatening to choke the lake *(West Australian,* August 10, 1972). The effect this had on the waterfowl has not been documented, but should be considered as being a possible agent for reduction of waterfowl numbers in the latter months of 1972. Also some time between 1971 and 1973 a black substance emanating from the dump on the margin of Lake Claremont was noticed by local residents (L. Quinlivan pers. comm.). Coincidental with this pollution, there was high mortality of the frog fauna at the lake.

In view of the fact that bird numbers in 1977 and 1974 are comparable, it is probable that Emory *et al.* in fact documented the recovery of the waterfowl population after the Lake Claremont ecosystem had been disturbed by some chemical agent.

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